NuMI MI62 LCW Controls

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Hardware

The MI62 LCW Control consists of an Automation Direct DL450 PLC mounted to a panel and wired to various field devices. Two text displays provide local access to pump status, instrumentation readings, and alarms in the controls/kicker room and in the pump room. A separate Moore Industries 535 PID-loop controller in conjunction with an EIM M2CP valve actuator regulates the LCW supply temperature. The PLC uses a front-end in an adjacent rack to communicate to consoles via ACNET.

All analog instrumentation sends a 4-20mA signal to the PLC for readback. The 535 receives the current loop from the LCW supply temperature gauge on the heat exchanger outlet and retransmits it to the PLC.

Loop powered field instruments are powered by a 24V supply on the PLC panel. This supply also powers the pump room display. Analog channels are fused in groups of 4 with 1/8A 3AG fast-blow fuses, except that the circuit powering the display is fused with 1/2A 3AG fast-blow.

The PLC IP is 131.225.., MI62-LCW-PLC, station 3.

Instrumentation List

Variable	Device	Location	Range (4-20mA)
LCW supply pressure	MSI/JL Electronics MSP400-400-P-5-N-5-0064A	Pump room	0-400 PSIG
LCW expansion tank air pressure	MSI/JL Electronics MSP400-400-P-5-N-5-0064A	Pump room	0-400 PSIG
LCW supply temperature	Reostat	Pump room	-40 to +160 deg F
LCW return temperature	Reostat	Pump room	-40 to +160 deg F
LCW supply reisistivity	Thornton 200CR	Pump room, box adjacent to DI bottles	0 to 18 megohm
DI bottle resistivity	Thornton 200CR	Pump room, box	0 to 18 megohm

		adjacent to DI bottles	
Expansion tank water level	Gems 52550	Pump room	0 to 30 inches
Pond water supply pressure	MSI/JL Electronics MSP400-400-P-5-N-5-0064A	Pump room, after strainer at inlet to heat exchanger	0-400 PSIG
LCW return pressure	MSI/JL Electronics MSP400-400-P-5-N-5-0064A	Pump room	0-400 PSIG
Pond pump suction pressure	?	PV9 vault	0-30 psiA
Pond supply pressure (before strainer)	MSI/JL Electronics ?	Pump room, at strainer inlet	0-300 PSIG
Pond water supply temperature	ReoTemp	Pump room, at strainer outlet	-40 to +160 deg F
Pond water discharge temperature	ReoTemp	Pump room, at heat exchanger outlet	-40 to +160 deg F
Three-way valve position	EIM H2CP	Pump room	0 to 100 percent
LCW1 motor current	Riley	MCC cabinet 2F	0 to 200 amps
LCW2 motor current	SV9000 drive	MCC cabinet 3M	0 to 250 amps
Pond A high speed current	Riley	MCC cabinet 1J	0 to 50 amps
Pond A low speed current	Riley	MCC cabinet 1J	0 to 30 amps
Pond B motor current	Riley	MCC cabinet 1L	0 to 50 amps
LCW1 motor temperature	Thermistor embedded in motor frame	LCW motor closest to MCC	550 to 1330 ohms at 140C, 250 ohms max at 25C
LCW2 motor temperature	Thermistor embedded in motor frame	LCW motor furthest from MCC	550 to 1330 ohms at 140C, 250 ohms max at 25C

PLC I/O Configuration

Slot	Device	Description
0	H4-ECOM	10Base-T Ethernet module
1	F4-16AD-1	16 channel current loop input module
2	F4-16AD-1	16 channel current loop input module
3	F4-08TRS-2	8 channel relay output module
4	F4-08TRS-2	8 channel relay output module
5	(open)	
6	(open)	
7	(open)	

Text display=Automation Direct EZ-420
Controls/kicker room display is on PLC RS232 port 0. Pump room display is on PLC RS422 port 3. Panels are read-only.
Watchdog Timer=Square-D Timer JCK22-14 modified for edge-triggering

PLC Program Overview

1. First scan

Initialization is done on the first scan after program reset and is listed at the top of the ladder. Scale factors and offsets, alarm limits, and time delays are set up. To make changing these values as easy and quick as possible, these constants are placed into V-memory locations rather than being sprinkled throughout the code. An additional benefit is that values can be changed on the fly without changing the program. All alarms are cleared, all motor RUN command and status flags are cleared, and the displays are initialized.

2. All subsequent scans

All rungs that execute every scan are placed after the initialization rungs but above all state machines.

V-mem locations corresponding to all 32 available analog inputs are refreshed with new raw readings. Each instrument reading is then converted to floating point format, scaled, and placed into ACNET accessible V-mem. Composite readings, such as differential pressure measurements, are then computed.

New values are compared against alarm limits. If a value remains outside of its nominal range for a time delay (typically 15 seconds), an alarm flag in the ACNET alarm word is set. For non-latching alarms, any measurement that returns to its nominal range resets its alarm flag and its delay timer.

All motor current alarms (pond and LCW) and “LCW supply temp out-of-range” alarm are latching and result in the shutdown of the corresponding motor. The shutdown must be acknowledged from ACNET before a motor or its companion can be re-started.

If the current in an LCW motor thermistor drops below a trip point, indicating that the motor itself is running hot, an alarm bit is set, the motor is shut down, and the trip point is decreased to create a hysteresis band. The initial trip point is restored once the motor cools below the new value. This keeps the motor from “short-cycling” as the temperature drifts about the shut-down temp.

“Motor running” status is determined by comparing the measured motor current to a minimum value and not directly from the controlling state machine. There can be a time lag between starting or stopping a motor and seeing its state change, particularly with the variable speed drive on LCW2.

Beam permit is assembled on every scan. The magnet power supply permit is simply a copy of the beam permit.

3. Motor State Machines

A state machine (SM) controls each motor. Each SM has five states: OFF, START,ON, and SHUTDOWN. The Pond-A motor is logically split into two independent machines - one for low-speed operation and one for high-speed operation. *Note that a motor's companion must be in the OFF state for it to run.*

A run permit must be assembled in the OFF state for the motor to advance to START.

In START, the run contacts are held long enough for the MCC to latch. Once in START, the motor will proceed to ON after a fixed delay. For LCW2, the duration is thirty seconds as the variable speed drive does not latch until the motor is almost up to full speed.

Shutdown flags and ACNET RUN/~STOP are monitored in the ON state.

If RUN/~STOP is deasserted, the SM enters the STOP state during which the normally closed stop contacts are held open long enough for the MCC to un-latch. Once in STOP, the motor will proceed to OFF after a fixed delay. Again, the variable speed drive does not unlatch until the motor is almost completely stopped and thus the delay is much longer than for the other motors.

If a shutdown condition occurs during ON, the SM moves to the SHUTDOWN state. RUN/~STOP is cleared, the shutdown alarm is set, and the stop contacts are held open. The contacts are released and the latched alarm is cleared only when the shutdown is acknowledged by ACNET. The SM then moves to OFF.

4. Watchdog Timer State Machine

The watchdog kicker cycles between IDLE and KICK every 20 seconds. *The hardware timer should be set to maximum delay*. If the PLC fails to kick the timer, the timer will expire and pull the beam permit.

5. Text Display

Both displays access the same V-mem locations and therefore act as if they are wired in parallel. Line #1 shows the ACNET tagname of the parameter, line #2 a brief description, and line #3 the current value. Line #4 shows the current status of the PLC beam permit. Even though messages are stored within the panel, the PLC must "push" message triggers to the panel.

F1 through F4 are programmed as “radio buttons” to select a group of parameters for display. Each button sets a C-mem bit that then directs execution to the appropriate rungs. Parameter display is implemented as a linked list of states that are stepped through by the up-arrow and down-arrow keys.

F5 is scanned only while Trips are being displayed on the panel (F4). Pressing F5 will clear all active trips. F5 allows a local operator to re-start the system without having to access an ACNET console.

The table that links alarm bits to their text messages is tacked on after the END statement and is loaded into V-mem at initialization.

6. LCW Low-Temperature Override Switch

The PLC will shut down the LCW motors if the water supply temperature drops below 60 degrees. An illuminated switch is provided in the rack for a local operator to override this trip to re-start the pumps and warm the water to normal operating range. This function is NOT available through ACNET.